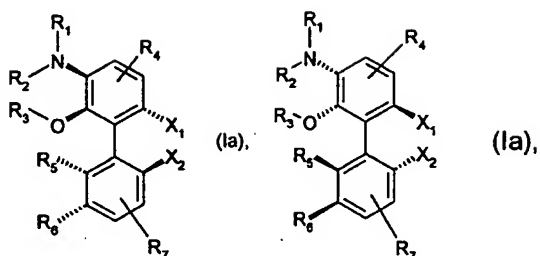


Claims:

1. A compound of the formula I,



where

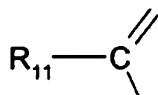
X<sub>1</sub> and X<sub>2</sub> are each, independently of one another, secondary phosphino;

R<sub>1</sub> and R<sub>2</sub> are each, independently of one another, hydrogen, C<sub>1</sub>-C<sub>8</sub>-alkyl, C<sub>3</sub>-C<sub>8</sub>-cycloalkyl, C<sub>3</sub>-C<sub>8</sub>-cycloalkyl-C<sub>1</sub>-C<sub>4</sub>-alkyl, C<sub>6</sub>-C<sub>10</sub>-aryl or C<sub>7</sub>-C<sub>11</sub>-aralkyl, or

R<sub>1</sub> and R<sub>2</sub> together are C<sub>4</sub>-C<sub>8</sub>-alkylene, 3-oxapentyl-1,5-ene, -(CH<sub>2</sub>)<sub>2</sub>-NH-(CH<sub>2</sub>)<sub>2</sub>- or -(CH<sub>2</sub>)<sub>2</sub>-N(C<sub>1</sub>-C<sub>4</sub>alkyl)-(CH<sub>2</sub>)<sub>2</sub>-,

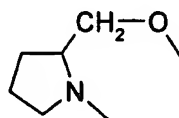
R<sub>3</sub> is hydrogen, C<sub>1</sub>-C<sub>8</sub>-alkyl, C<sub>3</sub>-C<sub>8</sub>-cycloalkyl, C<sub>3</sub>-C<sub>8</sub>-cycloalkyl-C<sub>1</sub>-C<sub>4</sub>-alkyl, C<sub>6</sub>-C<sub>10</sub>-aryl or C<sub>7</sub>-C<sub>11</sub>-aralkyl, or

R<sub>1</sub> is as defined above and R<sub>2</sub> and R<sub>3</sub> together are C<sub>2</sub>-C<sub>8</sub>-alkylidene, C<sub>4</sub>-C<sub>8</sub>-cycloalkylidene, C<sub>1</sub>-C<sub>4</sub>-alkylene, C<sub>2</sub>-C<sub>8</sub>-alk-1,2-enyl, -C(O)- or a group of the formula



or

R<sub>1</sub>R<sub>2</sub>N and R<sub>3</sub>O together are a group of the formula



R<sub>4</sub> and R<sub>7</sub> are each, independently of one another, hydrogen, C<sub>1</sub>-C<sub>4</sub>-alkyl, C<sub>1</sub>-C<sub>4</sub>-alkoxy, F, Cl or trifluoromethyl,

R<sub>5</sub> is hydrogen, R<sub>4</sub> or an R<sub>3</sub>O- group, where R<sub>3</sub>O- groups in the two rings can be identical or different,

R<sub>6</sub> is hydrogen, R<sub>7</sub> or an R<sub>1</sub>R<sub>2</sub>N- group, where R<sub>1</sub>R<sub>2</sub>N- groups in the two rings can be identical or different,

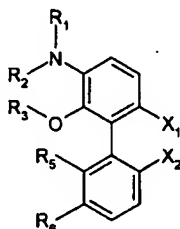
R<sub>5</sub> and R<sub>6</sub> together are trimethylene, tetramethylene or -CH=CH-CH=CH-, and

R<sub>11</sub> is C<sub>1</sub>-C<sub>8</sub>-alkyl, C<sub>3</sub>-C<sub>8</sub>-cycloalkyl, C<sub>3</sub>-C<sub>8</sub>-cycloalkyl-C<sub>1</sub>-C<sub>4</sub>-alkyl, C<sub>6</sub>-C<sub>10</sub>-aryl or C<sub>7</sub>-C<sub>11</sub>-aralkyl,

where R<sub>1</sub>, R<sub>2</sub>, R<sub>3</sub>, R<sub>4</sub> and R<sub>7</sub> are unsubstituted or substituted by C<sub>1</sub>-C<sub>4</sub>-alkyl, C<sub>1</sub>-C<sub>4</sub>-alkoxy, OH, F, Cl, Br, trifluoromethyl, C<sub>1</sub>-C<sub>4</sub>-hydroxyalkyl, -COOH, -SO<sub>3</sub>H, -C(O)O-C<sub>1</sub>-C<sub>4</sub>-alkyl, -SO<sub>3</sub>-C<sub>1</sub>-C<sub>4</sub>-alkyl, -C(O)-NH<sub>2</sub>, -CONHC<sub>1</sub>-C<sub>4</sub>-alkyl, -CON(C<sub>1</sub>-C<sub>4</sub>-alkyl)<sub>2</sub>, -SO<sub>3</sub>-NH<sub>2</sub>, -SO<sub>2</sub>-NHC<sub>1</sub>-C<sub>4</sub>-alkyl, -SO<sub>3</sub>-N(C<sub>1</sub>-C<sub>4</sub>-alkyl)<sub>2</sub>, -O<sub>2</sub>C-R<sub>8</sub>, -O<sub>3</sub>S-R<sub>8</sub>, -NH-(O)C-R<sub>8</sub>, -NH-O<sub>3</sub>S-R<sub>8</sub>, -NH<sub>2</sub>, -NHR<sub>9</sub> or -NR<sub>9</sub>R<sub>10</sub>, where R<sub>8</sub> is hydrogen, C<sub>1</sub>-C<sub>8</sub>-alkyl, C<sub>3</sub>-C<sub>8</sub>-cycloalkyl, C<sub>3</sub>-C<sub>8</sub>-cycloalkyl-C<sub>1</sub>-C<sub>4</sub>-alkyl, C<sub>6</sub>-C<sub>10</sub>-aryl or C<sub>7</sub>-C<sub>11</sub>-aralkyl, and R<sub>9</sub> and R<sub>10</sub> are each, independently of one another, C<sub>1</sub>-C<sub>4</sub>-alkyl, phenyl or benzyl or R<sub>9</sub> and R<sub>10</sub> together are tetramethylene, pentamethylene, 3-oxa-1,5-pentane or -(CH<sub>2</sub>)<sub>2</sub>-N(C<sub>1</sub>-C<sub>4</sub>-alkyl)-(CH<sub>2</sub>)<sub>2</sub>-.

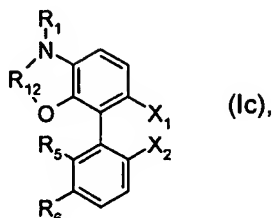
2. The compound as claimed in claim 1, characterized in that X<sub>1</sub> is a -P(R)<sub>2</sub> group and X<sub>2</sub> is a -P(R')<sub>2</sub> group, where R and R' are each, independently of one another, a hydrocarbon radical which has from 1 to 20 carbon atoms and is unsubstituted or substituted by halogen, C<sub>1</sub>-C<sub>6</sub>-alkyl, C<sub>1</sub>-C<sub>6</sub>-haloalkyl, C<sub>1</sub>-C<sub>6</sub>-alkoxy, C<sub>1</sub>-C<sub>6</sub>-haloalkoxy, -CO<sub>2</sub>-C<sub>1</sub>-C<sub>6</sub>-alkyl, (C<sub>6</sub>H<sub>5</sub>)<sub>3</sub>Si or (C<sub>1</sub>-C<sub>12</sub>-alkyl)<sub>3</sub>Si; or the radicals R and R' together are unsubstituted or C<sub>1</sub>-C<sub>4</sub>-alkyl- and/or C<sub>1</sub>-C<sub>4</sub>-alkoxy-substituted tetramethylene or pentamethylene.

3. The compound as claimed in claim 1, characterized in that it corresponds to the formula Ib,

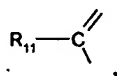


where R<sub>1</sub>, R<sub>2</sub> and R<sub>3</sub> are each, independently of one another, C<sub>1</sub>-C<sub>4</sub>-alkyl, R<sub>5</sub> is hydrogen or an OR<sub>3</sub> group, R<sub>6</sub> is hydrogen or an -NR<sub>1</sub>R<sub>2</sub> group, or R<sub>5</sub> and R<sub>6</sub> together are -CH=CH-CH=CH-, and X<sub>1</sub> and X<sub>2</sub> are secondary phosphino.

4. The compound as claimed in claim 1, characterized in that it corresponds to the formula Ic,

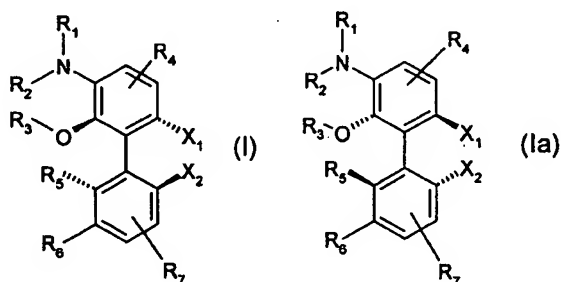


where R<sub>1</sub> C<sub>1</sub>-C<sub>4</sub>-alkyl, R<sub>5</sub> and R<sub>6</sub> are each hydrogen or R<sub>5</sub> and R<sub>6</sub> together are an -NR<sub>1</sub>-R<sub>12</sub>-O- group, X<sub>1</sub> and X<sub>2</sub> are secondary phosphino and R<sub>12</sub> is 1,2-ethylene, 1,2-ethenylene, -C(O)- or a group of the formula



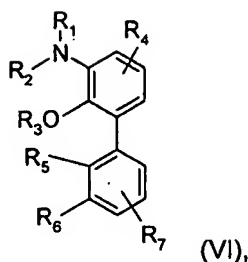
where R<sub>11</sub> is branched C<sub>3</sub>-C<sub>8</sub>-alkyl, C<sub>5</sub>-C<sub>6</sub>-cycloalkyl, phenyl or benzyl.

5. A process for preparing compounds of the formulae I and Ia,

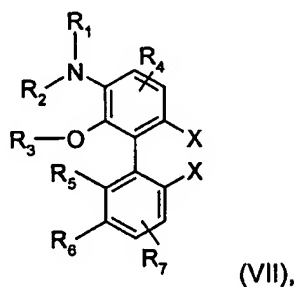


where R<sub>1</sub>, R<sub>2</sub>, R<sub>3</sub>, R<sub>4</sub>, R<sub>5</sub>, R<sub>6</sub>, R<sub>7</sub>, X<sub>1</sub> and X<sub>2</sub> are as defined in claim 1, which comprises the steps:

a) halogenation of a compound of the formula VI



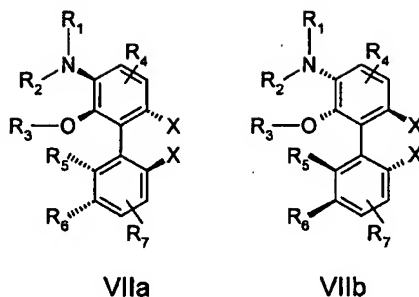
where  $R_1$ ,  $R_2$ ,  $R_3$ ,  $R_4$ ,  $R_5$ ,  $R_6$  and  $R_7$  are as defined above, or  $R_1$  is a protective group which can be split off and  $R_2$  is hydrogen or is as defined above, or  $R_3$  is a protective group which can be split off, or  $R_1$  and  $R_3$  together form a protective group which can be split off and  $R_2$  is hydrogen or is as defined above, by means of chlorine, bromine or iodine to form a compound of the formula VII



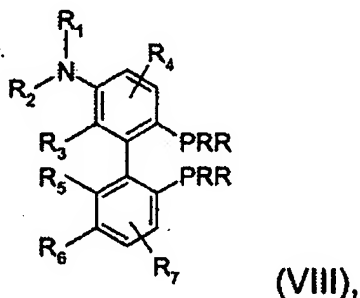
where X is chlorine, bromine or iodine,

b) if appropriate to introduce the radicals  $R_2$  and  $R_3$ , removal of the protective groups to form OH-functional and NH-functional groups and replacement of the H atoms in the OH-functional and NH-functional groups by means of a reagent  $R_2-X_2$ ,  $R_3-X_2$  or  $X_2-R_{13}-X_2$ , where  $X_2$  is a leaving group and  $R_{13}$  is 1,2-alkylene or 1,2-cycloalkylene, to produce compounds of the formula VII, and

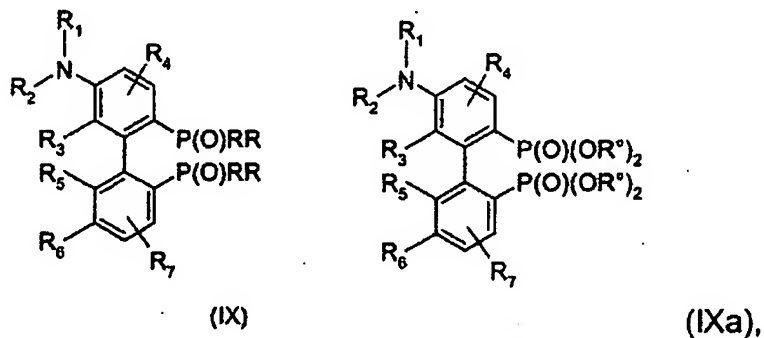
if appropriate resolution of the racemates of the formula VII to give the enantiomers of the formulae VIIa and VIIb

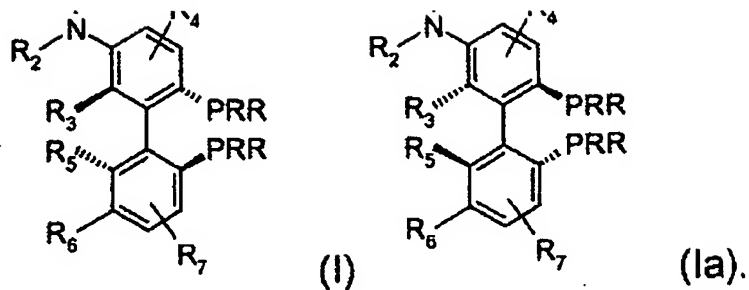


c) metalation of the compounds of the formula VII, for example by means of a lithium alkyl, and subsequent reaction with a halophosphine of the formula  $X_3\text{-PRR}$  ( $X_3$  is halogen) in the presence of a lithium alkyl to give diphosphines of the formula VIII, or with a halophosphine oxide of the formula  $X_3\text{-P(O)RR}$  to give diphosphine oxides of the formula IX, or with a phosphonate of the formula  $X_3\text{-P(O)(OR}^\circ)_2$  to give phosphonates of the formula IXa:



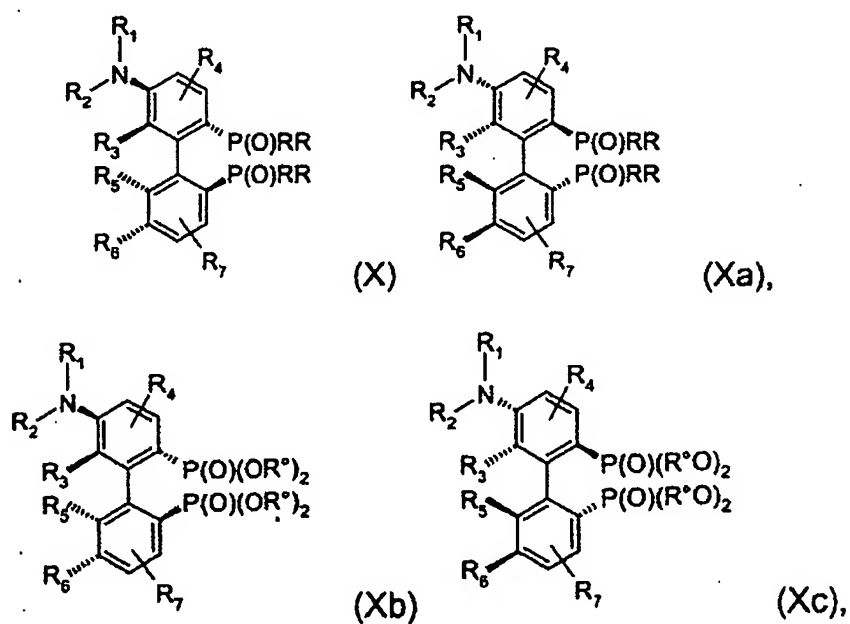
d) oxidation of the phosphine groups in compounds of the formula VIII by means of an oxidant to form compounds of the formula IX,





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e) if a racemic starting material of the formula VII is used resolution of the racemates of the formula VIII to give the enantiomers Ia and Ib, or resolution of the racemates of the formula IX to give the enantiomers of the formulae X and Xa, or resolution of the racemates of the formula IXa to give the enantiomers of the formulae Xb and Xc, and reaction of Xb and Xc with R-Mg-X to form phosphine oxides of the formula X and Xa,

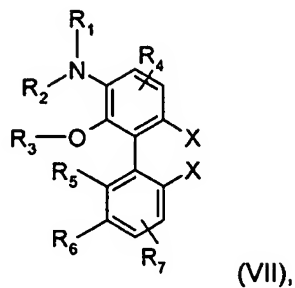


f) and reduction of the phosphine oxide group in the compounds of the formulae Xa and Xb to produce compounds of the formulae I and Ia.

R<sub>1</sub>

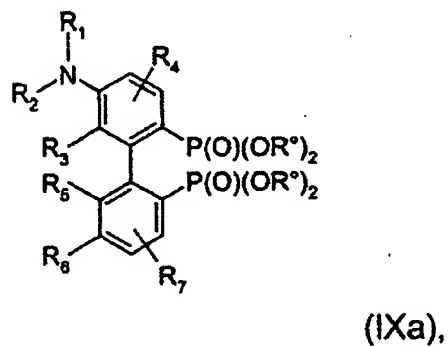
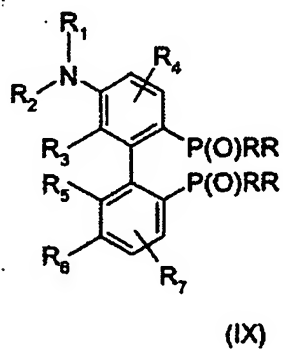
R<sub>1</sub>

6. A compound of the formula VII in the form of the racemate, optically enriched or optically pure form,

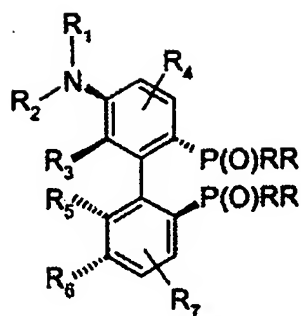


where  $R_1$ ,  $R_2$ ,  $R_3$ ,  $R_4$ ,  $R_5$ ,  $R_6$  and  $R_7$  are as defined in claim 1, or  $R_2$  is a protective group which can be split off or  $R_2$  and  $R_3$  together form a protective group which can be split off and  $R_1$ ,  $R_3$ ,  $R_4$ ,  $R_5$ ,  $R_6$  and  $R_7$  or  $R_1$ ,  $R_4$ ,  $R_5$ ,  $R_6$  and  $R_7$  are as defined in claim 1, and  $X$  is chlorine, bromine or iodine.

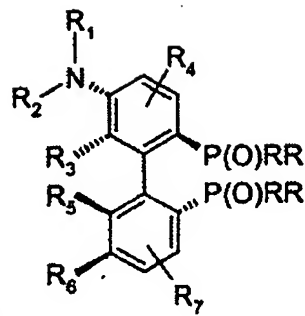
7. A compound of the formula IX in the form of racemates



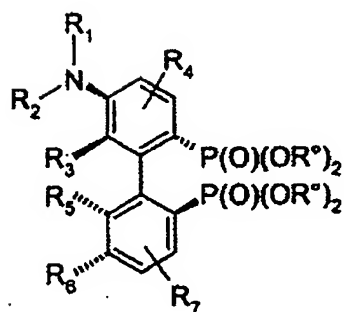
or an enantiomer of the formulae X, Xa, Xb and Xc,



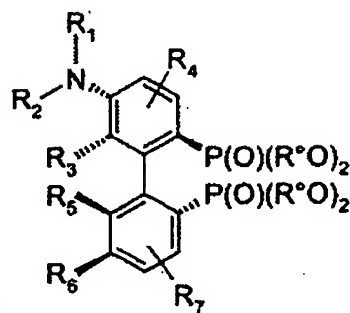
(X)



(Xa),



(Xb)

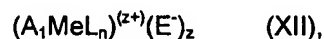


(Xc),

where  $R_1$ ,  $R_2$ ,  $R_3$ ,  $R_4$ ,  $R_5$ ,  $R_6$ ,  $R_7$  and  $R$  have the meanings indicated for the compounds of the formulae I and Ia, and  $R^*$  is  $C_1$ - $C_6$ -alkyl or phenyl.

8. A complex of a metal selected from the group of the TM8 metals with a compound of the formula I or Ia as claimed in claim 1 as ligand.

9. The metal complex as claimed in claim 8 which corresponds to the general formula XI or XII,



where  $A_1$  is a compound of the formula I or Ia as claimed in claim 1;

$L$  represents identical or different monodentate, anionic or nonionic ligands, or two  $L$  form identical or different bidentate, anionic or nonionic ligands;

$n$  is 2, 3 or 4 when  $L$  is a monodentate ligand or  $n$  is 1 or 2 when  $L$  is a bidentate ligand;

$z$  is 1, 2 or 3;